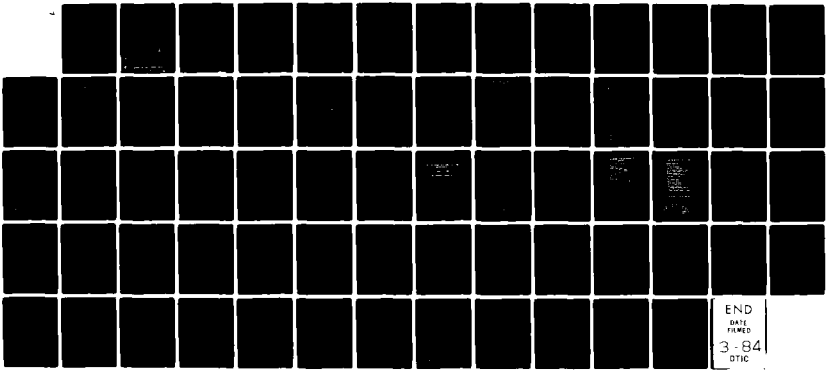
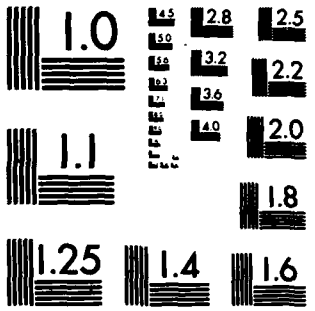
AD-A137 941 A SUMMARY OF PROCEEDINGS OF THE DEPARTMENT OF DEFENSE ROBOTICS APPLICATIO..(U) DEFENSE SYSTEMS MANAGEMENT COLL FORT BELVOIR VA 07 OCT 83 1/1

UNCLASSIFIED F/G 5/1 NL



END
DATE FILMED
3-84
DTIC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

(12)

A Summary
of
Proceedings
of the
Department of Defense Robotics Applications Workshop

Volume I

(Exclusive of Presentations)

A Summary

of

Proceedings

of the

Department of Defense Robotics Applications Workshop

Sierra Inn
Sacramento, California

October 4-7, 1983

Volume I

(Exclusive of Presentations)

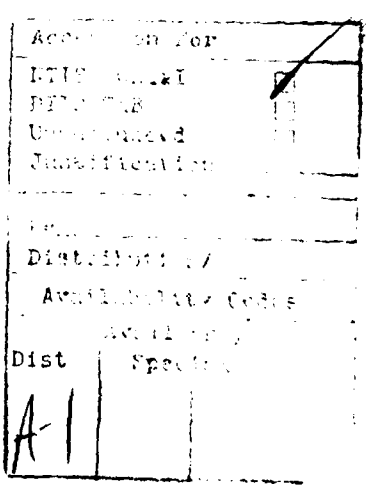


TABLE OF CONTENTS

VOLUME I

10. Current Successful Robot Applications - V. Scheinman
11. Robot Welding Systems - J. Fouse
12. The Future-Robotics in the Next Decade - M. Knasel
13. Air Force Aircraft Repair - G. Langenbeck
14. Air Force Engine Repair - M. LeBlanc
15. Air Force Electronics Repair - W. Ramsey
16. Air Force Landing Gear Repair - LTC Hruskocy
17. Navy Depot Processes - NARF Alameda
18. Navy Depot Processes - NARF Cherry Point - T. Tolson

VOLUME II

B. Presentations 19-47

19. Navy Depot Processes - NARF Jacksonville
20. Navy Depot Processes - NARF Norfolk - W. Maxwell
21. Navy Depot Processes - NARF North Island - CAPT P. Monroe
22. Navy Processes - NARF Pensacola
23. Navy Shipyard Processes - NSY Charleston
24. Navy Shipyard Processes - NSY Long Beach - Louis Smith & Les Hartzell
25. Navy Shipyard Processes - NSY Mare Island - Fred Henson
26. Navy Shipyard Processes - NSY Pearl Harbor - Joel Yuen
27. Navy Shipyard Processes - NSY Philadelphia
28. Navy Shipyard Processes - NSY Portsmouth - Ken Lanzillo
29. Navy Shipyard Processes - NSY Puget Sound
30. Exploration and Analysis of Letterkenny Army Depot Process Sequences - Steve Kalabokes
31. Current Operation and Economics of Welding, Plating, Painting, and Van Assembly - E. Helalian
32. Combat Vehicle Track and Suspension Overhaul and Conversion Operations at Red River Army Depot - W. Osterveen
33. Overhaul of Communications-Electronic Shelters at Tobyhanna Army Depot - F. Estock
34. Use of Robotics in Material Handling of Hazardous Materials - F. Eldredge
35. Navy Weapons Station Processes - NWS Charleston
36. Navy Weapons Station Processes - NWS Concord
37. Navy Weapons Station Processes - NWS Crane
38. Navy Weapons Station Processes - NWS Earle
39. Navy Ordnance Station Processes - NOS Indianhead
40. Navy Weapons Station Processes - NUWES Keyport
41. Navy Ordnance Station Processes - NOS Louisville
42. Navy Weapons Station Processes - NWS Seal Beach
43. Navy Weapons Station Processes - NWS Yorktown
44. Air Force Blade Repair - M. LeBlanc
45. Air Force, Plasma Spray at SA-ALC - S. Lee
46. Air Force, Honeycomb Shaping at SM-ALC - G. Betz
47. Air Force, Robotic Painting - COL R. Grabler

VOLUME III

C. Presentations 48-74

48. On-Aircraft Repair of P-3 Engine Shrouds at NARF Alameda - B. Savnik
49. Current Robotics Applications-Metal Spray Coating at NARF Cherry Point - J. O'Brien
50. Current Robotics Projects at NARF North Island - G. Tietje
51. Automated Wire Harness System and Combustion Chamber Processing -NARF Norfolk - W. Maxwell
52. Propeller Manufacturing at Philadelphia Naval Shipyard - J. O'Hagan
53. Naval Weapons Centers and Ordnance Activities-Robotics Projects - J. Johnson
54. Neo-Robotic Application Development-Agricultural Blastcleaning - J. Nitterhouse
55. Application of Robotics to Shelter Refinishing - S. O'Malley
56. Robotics Applications in Materials Handling - T. Kirkham
57. Automated Laser Paint Removal - T. Malletts
58. Air Force Materials Laboratory Plans and Projects - S. Lee
59. Aerospace Industrial Modernization and the Industry/Depot Robotics Survey - F. Brooks
60. Depot Robotics Plans and Needs at Ogden Air Logistics Center - LTC T. Ricosi
61. Robotics Plans and Applications at San Antonio Air Logistics Center - LTC D. Ferry
62. Robotics in Nondestructive Inspection at Sacramento Air Logistics Center - D. Froom
63. Naval Air Depot Automation and Robotics Application Plans - R. Wimmer
64. Shipyard Automation and Robotics Applications and Plans - R. Wells
65. Navy Robotics Planning and Shipyard Maintenance Applications - CDR B. Everett
66. Navy Ordnance Community Robotics Application Areas - H. Peesel
67. Naval Supply Center Robotics and Automation Plans - A. Senhen
68. Robotics-Aided Spare Parts Manufacturing Plans-Parts on Demand - R. Elwood
69. Robotics Applications in the Navy Public Works Centers - G. Meier
70. Robotics Systems Applications at Letterkenny Army Depot - J. Nitterhouse
71. Engineering Feasibility and Economic Considerations of Robotics Applications - Welding, Painting, etc. at Sacramento Army Depot - E. Helalian
72. Single/Double Pin Track Vehicle Denuding, Disassembly, Hull Welding, and Automation Applications at Red River Army Depot - W. Osterveen
73. Field Applications for Robotic Material Handling Systems - F. Eldridge
74. Robotics Gage Block Standards Calibration - D. Shimek

D. Round Table Sessions

1. Round Table Leaders Guide
2. Workshop Round Table Material (Participants)
3. Round Table Summary Results

E. DOD Robotics Workshop Attendees List

FOREWORD

The proceedings of the DOD Robotics Applications Workshop contain presentations and summaries of material offered at the workshop. There were 74 formal day presentations, eight roundtable summary presentations, and ten evening presentations offered in the three-day workshop period; in all, more than 46 hours of presentations and discussion.

Not all speakers offered hard copy material of presentation graphics. However, all formal day sessions were audiotaped. Thus, wherever hard copy was not provided, a brief summary of what was offered has been reconstructed from the corresponding audiotape and included in the proceedings. The material submitted by the presenters has generally been reproduced as received, except where the graphic quality of the submittal mandated that minor retyping or enhancement be effected to assure reproduceability.

The proceedings are organized to follow the flow of the workshop. An Executive Summary is provided at the beginning of Volume I and includes: (1) material on the DOD organic industrial base and its operations and processes; (2) a listing of current major DOD industrial robotics projects; and (3) the menus of needs, issues, and project ideas developed by the eight roundtables for the ten technical topic areas. The roundtable menus constitute the primary product of the workshop.

Following the Executive Summary is introductory material describing the genesis of the workshop and its organization. Abstracts of private sector expert briefs and the operations and processes briefs of the DOD activities constitute the balance of Volume I (Presentations 1-18).

Volume II (Presentations 19-47) contains material offered by DOD activities on current robotics projects and plans for the future. Volume III (Presentations 48-74) contains the balance of the DOD current projects/future plans material, the roundtable output summaries, and a list of workshop attendees. Bon appetit!

EXECUTIVE SUMMARY

The DOD Robotics Applications Workshop was held October 4-7, 1983 at the Sierra Inn, Sacramento, California. The event was co-hosted by the Air Force Sacramento Air Logistics Center and the Sacramento chapter of the Society of Logistics Engineers (SOLE). The workshop brought together for the first time private sector experts and engineering and senior management representatives from all the industrial activities of the three services save one (Norfolk Naval Shipyard) to focus on a leading edge industrial technology. This had never been done before. More than two hundred attendees (180 + formal registrants) from army depots and arsenals, navy shipyards, air rework facilities, weapons stations and ordnance activities, supply centers, public work centers, air force logistics centers, the Defense Logistics Agency, DOD, etc., received briefs on the state-of-the-art, current practice, successful implementations, and current research and research directions in robotics from 13 private sector experts chosen by the Robot Institute of America (RIA).

Next, attendees selected by the represented DOD Industrial activities presented the industrial processes and process economics of their industrial operations to the audience. Current robotics projects and project plans for robotics and automation for both the near term and the future were also offered by the attending DOD activities.

Finally, the resultant elevated knowledge base and collective expertise of both the private sector and public sector attendees were applied in three dimensions (current applications, technology transfer/manufacturing technology needs, and research issues and needs) in ten technical topic areas by eight groups of attendees in a unique brainstorming roundtable format. The result was a knowledgeably ranked menu of potential robotics-related investments which represent an extraordinary and stunning opportunity to enhance the productivity, performance, and capability of the Department of Defense organic industrial base over the next decade.

The ten robotics-related technical areas addressed were: (1) Applications; (2) Installation/Design Concepts; (3) Safety and Security; (4) Languages; (5) Controls and Integrated Systems; (6) Mechanical Systems and Precision Operations; (7) Vision Systems; (8) Hands and End Effectors; (9) Sensors; and (10) Transportability/Mobility. That robotics is a systems issue embedded in an automation framework is most apparent because the roundtable-developed menus in these ten technical areas show considerable interaction and overlap. However, a remarkable range of distinct applications, needs, and potential project investments emerged in each technical area, many of which were unique and did not overlap the concepts developed in other roundtables. Each workshop participant was afforded the opportunity to participate in three roundtables of choice, and thus each technical area was brainstormed, discussed and the resultant product rated by three different groups of DOD participants utilizing for each iteration the same private sector expert as leader/facilitator.

Following this narrative is a workshop summary which outlines the needs, issues, and priorities developed by workshop attendees in each of the aforementioned technical areas. The summary is in essence an investment planning guide in robotics and automation systems for the entire DOD in-house industrial base, and should prove to be a valuable resource not only to DOD technology and capital investment planners but also to the robotics industry and academia as they attempt to assess and plan product development, research, and technology transfer (mantech) needs and priorities in support of the DOD organic industrial base.

CONCLUSIONS

- ROBOTICS IS A SEMINAL DEPOT TECHNOLOGY
- IDEAL ENVIRONMENT: LABOR INTENSIVE BUSINESS
- BROADEST POSSIBLE ROBOTICS APPLICATION PANORAMA
- EXTRAORDINARY POTENTIAL EXISTS FOR CURRENT IMPLEMENTATIONS
- MANY MANTECH PROJECT OPPORTUNITIES
- MUCH BUSINESS-SPECIFIC R&D NEEDED
- HEAVY SPILLOVER TO PRIVATE SECTOR APPLICATIONS
- NEW ECONOMIC MODELS NEEDED FOR SMART AUTOMATION INVESTMENTS
- INVESTMENT PLAN INTEGRATED WITH OVERALL MODERNIZATION/AUTOMATION OBJECTIVES NEEDED
- DEPOT PROCESS ARCHITECTURE MODEL NEEDED
- ROBOTICS IS A SYSTEMS ISSUE (AN EMBEDDED TECHNOLOGY)
- GENERIC APPROACHES TO INTEGRATION OF PROCESS, INTERFACES, ROBOTICS NEEDED

RECOMMENDATIONS

- AGGRESSIVELY PURSUE CURRENT INVESTMENT OPPORTUNITIES
- DEVELOP NEW ECONOMIC JUSTIFICATION MODEL (A LA IBM)
- DEVELOP COORDINATED TRI-SERVICE ROBOTICS R&D AND MANTECH PLAN
- AGGRESSIVELY PURSUE ROBOTICS MANTECH INITIATIVES
- DEVELOP DOD ROBOTICS R&D PROGRAM ELEMENT
- FUND DOD ROBOTICS R&D INVESTMENT LINE FOR TRI-SERVICE COMPETITION
- CONSIDER ROBOTICS AS COMPONENT OF OVERALL OVERHAUL, REPAIR, REMANUFACTURING SYSTEM (CIM)
- INITIATE PROJECT TO MODEL ARCHTYPE OVERHAUL, REPAIR, REMANUFACTURING ARCHITECTURE (HIERARCHICAL CONTROL)
- INITIATE DECADE-LONG PLAN TO IMPLEMENT HIERACHICAL CONTROL AUTOMATION ARCHITECTURE IN DOD DEPOTS
- SOLICIT/INVOKE SUPPORT OF THE CONGRESS FOR JOINT INDUSTRY/ACADEMIA/DOD ROBOTICS/AUTOMATION INVESTMENT ALLIANCE
- USE DOD ROBOTICS WORKSHOP PROCEEDINGS AS REFERENCE PLANNING GUIDE FOR DOD ROBOTICS PROGRAM

THE DOD ORGANIC INDUSTRIAL BASE

- AIR INDUSTRIAL ACTIVITIES
- PRODUCTION ARSENALS
- PRODUCT LINE DEPOTS
- SHIPYARDS
- WEAPONS STATIONS/ORDANCE ACTIVITIES
- SUPPLY CENTERS
- MAINTENANCE/PUBLICK WORKS CENTERS
- LABORATORIES WITH PRODUCTION/SUPPORT OPERATIONS

THE BUSINESS

- VOLUME: $10B/YEAR
- OVERHAUL
- REPAIR
- REMANUFACTURING
- MANUFACTURING (ORDNANCE)
- ENGINEERING/TECHNICAL SERVICES
- SUPPLY SUPPORT
- FACILITY MAINTENANCE AND SUPPORT

THE PRODUCTS

- TACTICAL VEHICLES
- AIRCRAFT
- SHIPS
- WEAPONS SYSTEMS
- ORDNANCE AND ORDNANCE SYSTEMS
- SUPPORT EQUIPMENT AND SYSTEMS
- SPARES AND PIECE PARTS
- TECHNICAL SERVICES AND DATA
- COMMUNICATIONS/ELECTRONICS
- SUPPLY INVENTORY/PERSONNEL ASSETS
- MISSILES

THE ORGANIZATION

- PROCUREMENT/SUPPLY
- PRODUCTION PLANNING AND CONTROL
- TRANSPORTATION
- PRODUCTION
- ENGINEERING
- QUALITY ASSURANCE
- FINANCIAL AND COMPTROLLER
- ADMINISTRATIVE SERVICES
- TEST AND SELLOFF
- PACKAGING AND PRESERVATION
- MEASUREMENT AND STANDARDS

TYPICAL DOD DEPOT PROCESSES

- MATERIAL HANDLING/STORAGE
- MATERIAL TRANSFER/LOADING/UNLOADING
- PALLETIZING
- MACHINE LOADING
- FORGING
- DIE CASTING
- INVESTMENT CASTING
- MOLDING
- METAL FABRICATION/MACHINING
- DISASSEMBLY
- ASSEMBLY
- CIRCUIT BOARD HANDLING
- ELECTRONIC COMPONENT INSERTION
- WIRE HARNESS MANUFACTURE
- DRILLING/ROUTING
- CUTTING/BURNING
- TESTING, MECHANICAL
- TESTING, ELECTRONIC
- WELDING
- JOINING
- PAINTING
- COATING
- FACING/HARDENING/TREATING
- INSPECTION
- PACKAGING
- MATERIAL APPLICATION
- COMPOSITE LAYOUT
- DELIVERY
- SORTING
- CLEANING
- SECURITY
- TOOL CONTROL
- ANTHROPOMORPHIC EQUIPMENT OPERATION
- OTHER

CURRENT/PLANNED DEPOT ROBOTICS PROJECTS

PROJECT	SERVICE
TURBINE BLADE REPAIR	AIR FORCE
PLASMA SPRAY	AIR FORCE
FINISHING	AIR FORCE
HONEYCOMB SHAPING	AIR FORCE
SAND BLASTING/CLEANING	AIR FORCE
REAL TIME X-RAY	AIR FORCE
LASER PAINT REMOVAL	AIR FORCE/NAVY
ROBOTIC PAINTING	AIR FORCE/NAVY/ARMY
RIVETING/DERIVETING	NAVY
WIRE HARNESS MANUFACTURE	NAVY
NEUTRON RADIOGRAPHY INSPECTION	NAVY
SEAM WELDING/CUTTING	NAVY
SMALL STRUCTURE WELDING	NAVY/ARMY
VEHICLE SUSPENSION/TRACK DISASSEMBLY	ARMY
SHELTER REFINISHING	ARMY
VAN ASSEMBLY	ARMY
HAZARDOUS MATERIALS HANDLING	ARMY

ROUNDTABLE TOPICS

- APPLICATIONS
- INSTALLATION/DESIGN CONCEPTS
- SAFETY AND SECURITY
- LANGUAGES
- CONTROLS AND INTEGRATED SYSTEMS
- MECHANICAL SYSTEMS/PRECISION OPERATIONS
- VISION SYSTEMS
- HANDS AND END EFFECTORS
- SENSORS
- TRANSPORTABILITY/MOBILITY

PRIVATE SECTOR PRINCIPALS

o	VERN ESTES (G.E.)	APPLICATIONS
o	DAVID ANDERSON (FORD)	APPLICATIONS
o	RICHARD HOHN (CINCINNATI MILLICRON)	INSTALLATION/DESIGN CONCEPTS, SAFETY/ SECURITY
o	ROBERT TROUTEAUD (ROBOT SYSTEMS, INC.)	INSTALLATION/DESIGN CONCEPTS, SAFETY/ SECURITY
o	ROGER NAGEL (LEHIGH UNIV.)	LANGUAGES, CONTROLS INTEGRATED SYSTEMS
o	JOHN EVANS (NOVA ROBOTICS)	LANGUAGES, CONTROLS, INTEGRATED SYSTEMS
o	DELBERT TESAR (UNIV. OF FLORIDA)	MECHANICAL SYSTEMS, PRECISION OPERATIONS
o	HOWARD STERN (ROBOTIC SYSTEMS, INC.)	VISION SYSTEMS
o	RONALD HILLS (GENERAL DYNAMICS)	HANDS AND END EFFECTORS
o	VICTOR SCHEINMAN (AUTOMATIX)	SENSORS
o	MICHAEL KNASEL (SAI, INC.)	TRANSPORTABILITY/MOBILITY

APPLICATIONS - SESSIONS 1 & 2

1. PAINT/DEPAINT
2. INSPECTION
3. X-RAY INSPECTION
4. MIG/TIG LASER WELDING
5. RIVET/DERIVET
6. ASSEMBLY/DISASSEMBLY
7. WIRE HARNESS ASSEMBLY
8. FIRE FIGHTING
9. COMPOSITE LAY-UP
10. GUN LOADING

UNRANKED APPLICATIONS - SESSIONS 1 & 2

- STENCILING, MARKING
- SHOT PEENING
- DEBURRING
- CLEANING
- MIXING
- BOX FABRICATION
- WATER JET CUTTING
- PACKAGING

APPLICATIONS - SESSION 3

1. PAINT/DEPAINT
2. GRIT BLAST
3. DEMENSIONAL INSPECTION
4. X-RAY INSPECTION
5. MIG/TIG, LASER WELDING
6. RIVET/DERIVET
7. ASSEMBLY/DISASSEMBLY
8. THERMO/PLASMA SPRAY
9. CALIBRATION/TEST
10. PACK, DEPACK, PALLETIZING

APPLICATIONS - GENERAL COMMENTS

- ECONOMIC JUSTIFICATION DIFFICULT
  - ANS: MULTIPLE USE/APPLICATIONS
- ELECTRONIC REPAIR - UNIVERSAL ROBOTICS NEED
- ROBOTICS PRECISION PARTS HANDLING -UNIVERSAL NEED
- PARTS DESIGNED FOR AUTOMATION -UNIVERSAL NEED
- HIGH MOBILITY ROBOTICS - UNIVERSAL NEED

INSTALLATION/DESIGN CONCEPTS AND SAFETY/SECURITY

- o VENDOR CHOICE CRITERIA
- o PRE AND POST INSTALLATION TRAINING
- o INTERFACE WITH OLDER EQUIPMENT
- o HUMAN FACTORS
- o CRITERIA FOR TURN KEY SYSTEMS
- o FEEDING MECHANISMS TO ROBOT
- o ROBOT LAY-OUT
- o ROBOT SERVICE, LIFE-HOSTILE ENVIRONMENT
- o CAD/CAM, ATE, INSPECTION INTERFACE
- o FLEXIBILITY FOR SMALL BATCH
- o ADVANCE SENSOR INTERFACING
- o WAREHOUSING AUTOMATION
- o EXPLOSION PROOFING
- o MOBILITY, POWER
- o NEW MECHANICAL ROBOT DESIGN
- o SENSOR INTERFACING
- o HUMAN SAFETY
- o PART/MACHINE SAFETY
- o PAINTING/STRIPPING CELL--SMALL PARTS
- o SYSTEM MAINTAINABILITY
- o DERIVETING
- o MULTI-USE SYSTEMS
- o LOW VOLUME INSPECTION

INSTALLATION/DESIGN CONCEPTS AND SAFETY/SECURITY (CON'T)

- FUEL/MANIFOLD ASSEMBLY
- LARGE PAINTING/STRIPPING CELL
- ROBOT SYSTEMS APPROACHES
- PLATING CELL
- BRAKE SHOE CELL
- FOAM-IN-PLACE PACKAGING
- VEHICLE/TRUCK ASSEMBLY
- MANUFACTURING OF WOOD SHIPPING CONTAINERS
- BEARING INSPECTION/MATCHING
- BLACK AND VANE CELL SYSTEM
- ROBOTIC INTERIOR/CONTAINER COATING
- KITTING
- CIRCUIT BOARD TESTING/REPAIR SYSTEMS
- SURFACE MEASUREMENT
- SMALL SHIPBOARD ROBOTICS SYSTEMS
- SYSTEMS CONTROL INTERFACES
- GUIDELINES FOR SYSTEMS SPECIFICATIONS
- ROBOTICS SECURITY/SAFETY DESIGN CONCEPTS
- INTEGRATED SYSTEM DESIGN: MIS, FMS, CIM
- SOLDER/DESOLDER SYSTEM
- OPERATING ENVIRONMENT SPECIFICATION
- AUTOMATED NDI/TEST
- PIPE PREP, WELD, NDT
- INTERIOR TANK PORTABLE SERVICE ROBOTICS
- CO-ORDINATED MULTI-ARM ROBOT SYSTEMS
- STANDARDIZED SOFTWARE

LANGUAGES, CONTROLS, INTEGRATED SYSTEMS
PROCESS - TECHNOLOGY MATCHES

1. LOAD MACHINE WITH MOVING TURNTABLE (EXPLOSIVE)
2. ADAPTIVE PROCESS APPLICATIONS (WELDING, PAINTING, GRINDING)
3. MOVE BOXES WITH VARIABLE DIMENSIONS
4. ENGINE PARTS PAINTING
5. ENGINE PARTS INSPECTION
6. GAUGE BLOCK CALIBRATION
7. MACHINE TENDING -NC CELLS
8. BLASTING OF SIMPLE SURFACES
9. PAINTING SIMPLE PREDICTABLE GEOMETRIES
10. BEARING INSPECTION - SIMPLE ACCEPTANCE CRITERIA
11. INSTRUMENT SOLDERING AND DESOLDERING - SIMPLE

MANUFACTURING TECHNOLOGY NEEDS

1. MOVE BOXES WITH HIGHLY VARIABLE DIMENSIONS
2. DISASSEMBLY OF SIMPLE ELECTRONICS PACKAGES/DEVICES
3. BLASTING OF IRREGULAR SURFACES WITH CONSTRAINTS (AVOID NAME PLATES)
4. DISASSEMBLY AND CLEANING OF FUEL MANIFOLD NOZZLES
5. PAINTING COMPLEX SURFACES, COLORS, PATTERNS
6. BEARING INSPECTION AND CLEANING - MULTIPLE ACCEPTANCE CRITERIA
7. INSTRUMENT SOLDERING AND DESOLDERING - COMPLEX
8. WHOLE AIRCRAFT PAINTING/MARKING
9. SURFACE INSPECTION AND DEFECT MARKING
10. REPAIR OF COMPOSITES
11. INTEGRATED INSPECTION, DATA STORAGE SYSTEM
12. NEUTRON RADIOGRAPHY - CONTROLS
13. LASER PAINT STRIPPING - CONTROLS
14. CONFORMAL COATING REMOVAL
15. CONTROL/PROGRAMMING FOR LOW VOLUME PLASMA COATING
16. INTEGRATION OF COMPLEX SENSORS AND VISION WITH ROBOT CONTROL
17. STANDARDIZED PROGRAMMING TECHNOLOGY
18. INTEGRATED CAD/CAM DATA - ROBOTICS SYSTEMS
19. GROUP TECHNOLOGY - PROCESS PLANNING DATA INTEGRATION
20. STANDARD INTERFACES TO SENSORS, DATA BASES, ETC.
21. SMALL PARTS NDI
22. GENERAL PURPOSE CIRCUIT BOARD SCREENING

LANGUAGES, CONTROLS, INTEGRATED SYSTEMS (CON'T)
R&D NEEDS

1. DISASSEMBLY OF COMPLEX PACKAGES/DEVICES
2. ASRS BIN/ITEM PICKING
3. SHEET METAL FABRICATION, CUTTING, BENDING VIA CAD/CAM LINKS
4. WHOLE AIRCRAFT PAINTING/DEPAINTING
5. MAN-MACHINE GENERIC CONTROL SYSTEM FOR FIELD APPLICATIONS
6. COMPOSITES REPAIR
7. INTEGRATED INSPECTION DATA/MACHINE TOOL DRIVER SYSTEM
8. INTEGRATION OF ROBOT VISION WITH CONTROL
9. TASK PROGRAMMING WITH MAN-MACHINE INTERFACE (SHOP FLOOR)
10. FUNCTIONAL PROGRAMMING
11. GROUP TECHNOLOGY INTERFACE
12. CO-ORDINATED CONTROL OF MULTIPLE ROBOTIC DEVICES

SUMMARY R&D NEEDS

- REQUIREMENTS DEFINITION AND STANDARD PROGRAM METHODOLOGY
- COMMUNICATION STANDARDS BETWEEN ROBOT CONTROL AND SUPERVISORY CONTROL (STD. INTERFACES)
- THREE DIMENSIONAL IGES DEVELOPMENT

MECHANICAL SYSTEMS/PRECISION OPERATIONS

NEED/OPERATION	----RATINGS---- ROI VALUE	MANTECH AVAILABILITY	R&D LEVEL REQUIRED (AVAIL)
PRECISION WELDING AND GRINDING (TURBINE BLADES)	3	1	10(0)
PRECISION INSPECTION AND QUALITY MEASUREMENT	2	2	6(4)
PRECISION DRILLING OF STRUCTURES	4	5	9(1)
DERIVITING/RIVETING	5	6	8(2)
MECHANICAL ASSY/DISASSY	1	4	1(9)
HAZARDOUS OPERATIONS/MUNITIONS	6	3	5(5)
PRECISION ROUTING/TRIMMING (AIRFRAME SURFACE PANELS)	7	8	7(3)
SURFACE PATCHING FOR COMPOSITE STRUCTURES AND HONEYCOMB PANELS	9	7	4(6)
AVIONICS/ELECTRONICS MODULE MAINTENANCE	8	9	3(7)
NUCLEAR REACTOR MAINTENANCE	10	10	2(8)

VISION SYSTEMS

APPLICATIONS

- RECEIVING-BOX SIZE
- INVENTORY
- SEWER INSPECTION
- SEAM TRACKING-IRREGULAR SHAPES - ALUMINUM
- SMALL PARTS INSPECTION
- AIRCRAFT SURFACE INSPECTION
- SMALL PARTS ASSEMBLY
- PART MEASUREMENT
- PACKAGING
- PROFILE
- PALLETIZING
- LOAD/UNLOAD CAROUSEL CONVEYORS
- PARTS/DIMENSION REPLICATION
- ORDER PICKING
- LARGE PART LOCATION AND SUBFEATURES
- BAR CODE LOCATION/OPERATIONS
- BIN PICKING
- PC BOARD INSPECTION
- COLOR IDENTIFICATION

VISION SYSTEMS (CON'T)

MANTECH NEEDS

- o INSPECTION OF VERY LARGE OBJECTS
- o CONTINUOUS WELDING
- o SMALL COMPONENTS INSPECTION
- o DERIVETING/FASTENER REMOVAL
- o TOOL GUIDANCE
- o FASTENER LOCATION
- o WEAPON LOADING
- o FIRE FIGHTING
- o AIRCRAFT COMPONENT ASSEMBLY
- o GMA WELDING
- o REAL TIME VISUAL DATA ACQUISITION
- o PART IDENTIFICATION

VISION SYSTEMS (CON'T)

R&D NEEDS

- o SORTING (COMPLEX GEOMETRIES)
- o WELDING
- o FASTENER IDENTIFICATION
- o CONTOUR FOLLOWING (FOR PAINTING, CORE REPAIR)
- o INSPECTION FOR DISASSEMBLY/ASSEMBLY
- o PRECISION INSPECTION
- o MACHINE LOADING
- o LOADING - TOOL CHANGING
- o BAR CODE OPERATIONS
- o SURFACE QUALITY AND PREPARATION
- o PATTERN ASSEMBLY
- o MAGNAFLUX INSPECTION
- o PART RECOGNITION
- o SAFETY AND SECURITY SYSTEMS
- o 3D REPLICATION (PARTS ON DEMAND)

VISION SYSTEMS

CURRENT TECHNOLOGY	POTENTIAL APPLICATION	LIMITATIONS
2D BINARY VISION	———	AMBIGUITY SURFACE . . REFLECTANCE
2D GRAY SCALE VISION	———	AMBIGUITY
3D (DOT-LINE SENSOR)	GRINDING, DRILLING, ETC.	DAYLIGHT, SHADOWING
3D (PLANER-CCD CAMERA)	GRINDING, DRILLING, PARTS MFG., MOBILE ROBOT	DAYLIGHT, SHADOWING
3D (STEREO)	———	COMPUTATIONALLY INTENSIVE
3D (MULTIPLE PLANES)	AS ABOVE; MOBILE ROBOT	DAYLIGHT, SHADOWING

VISION SYSTEMS

CURRENT TECHNOLOGY	APPLICATION AREA	SPECIFIC APPLICATION
2D BINARY VISION	INSPECTION, MEASUREMENT	SORTING, ASSEMBLY . .
2D GRAY SCALE VISION	DITTO	DITTO, PLUS BIN PICKING
3D (DOT-LINE SENSOR)	DEPTH GAGING AND CONTOUR	SCANNING
3D (PLANER-CCD CAMERA)	CONTOURING	MEASUREMENT, WELD TRACKING, INSPECTION
3D (STEREO)	MEASUREMENT	MAPPING, INSPECTION
3D (MULTIPLE PLANES)	SURFACE MEASUREMENT	COPYING, INSPECTION, MEASUREMENT

VISION SYSTEMS

CURRENT RESEARCH

- COLLISION AVOIDANCE
- GEOMETRIC REASONING
- PLANNING AND STRATEGIES
- RECOGNITION
- APPLICATIONS OF 3D VISION
  - INSPECTION/MEASUREMENT
  - WIRE HARNESSING
  - GRINDING
  - WELDING
  - MATERIAL HANDLING
  - ASSEMBLY/DISASSEMBLY
  - DRILLING/ROUTING

HANDS AND END EFFECTORS

PROCESS APPLICATIONS

1. MATERIALS HANDLING
2. MACHINE LOAD
3. WELDING
4. PAINTING
5. STRIPPING/DEPOSITING
6. CLEANING/BLASTING
7. METAL SPRAY
8. SHOT PEENING
9. GRINDING
10. CUTTING
11. INSPECTION
12. DISASSEMBLY
13. ASSEMBLY
14. DEBURRING
15. MASKING

MANTECH NEEDS

1. ASSEMBLY/DISASSEMBLY (COMPONENTS)
2. WIRE HARNESS ASSEMBLY
3. INSPECTION/GAGING
4. MARKING/ENGRAVING (LASER/OTHER)
5. LASER WELDING
6. MATERIAL APPLICATION

R&D NEEDS

1. ASSEMBLY/DISASSEMBLY (LARGE AND SMALL ITEMS)
2. WIRE HARNESS ASSEMBLY
3. AUGMENTED END EFFECTOR STRUCTURES
   - o VISION AUGMENTED
   - o TACTILE AUGMENTATION
   - o ADAPTIVE MECHANISMS
   - o LASER INTEGRATION
4. UNIVERSAL AND FLEXIBLE STRUCTURES
5. MULTIHAND STRUCTURES (AND INTEGRATED CONTROL SYSTEMS)

SENSOR SYSTEMS

PROCESS APPLICATIONS

- AUTOMATED NDI
- WELDING
  - SEAM TRACKING
  - WELD QUALITY
- ASSEMBLY/DISASSEMBLY
  - CLOSE TOLERANCE PARTS
  - INCIPIENT DAMAGE
  - INSPECTION AND REPAIR
- BIN PICKING AND SORTING
- PACKAGING
  - SELECTING METHOD, ORIENTATION, ETC.
- RIVETING/DERIVETING
  - MATERIAL
  - TYPE
- PAINTING
  - SURFACE TRACKING
  - SURFACE FEATURES
- NON-CONTACT 3D GAGING
- GRINDING AND POLISHING
- SOLDERING/DESOLDERING
  - PRESENCE OF SOLDER
  - FLUID DISPENSE VERIFICATION
- SECURITY SYSTEM - INTRUSION
- PWB ASSEMBLY
- CHEMICAL/PHYSICAL MIXING
- FUEL LEAK DETECTION

SENSOR SYSTEMS

MANTECH NEEDS

- GENERIC SENSOR INTERFACES
- NDI SENSORS FOR ROBOTS (ALL TYPES)
- INTEGRITY SENSOR
- TACTILE MATERIAL HANDLING SENSORS
- REAL TIME WELD PARAMETRIC SENSORS
- COMPOSITE MATERIAL COMPOSITION SENSOR
- FUEL LEAK DETECTION FOR ROBOT APPLICATION

R&D NEEDS

- HOLOGRAPHIC PARTS ID
- FAST MATERIAL COMPOSITION ANALYSIS
- INTEGRATED FLOW DETECTION AND REPAIR CAPABILITY
- TASK-SPECIFIC SENSORS
- INTEGRATED SENSOR SYSTEMS
- ENABLING SENSOR DEVELOPMENTS

TRANSPORTABILITY AND MOBILITY

APPLICATIONS

- PAINTING
- WELDING
- SANDING/BLASTING
- MULTI-STATION SYSTEMS
- AMMUNITION HANDLING
- NUCLEAR HARDENING
- FIREFIGHTING
- ORDNANCE LOADING/UNLOADING
- FLEXIBLE MACHINING/MFG SYSTEMS
- CHEMICAL CLEANUP/CLEANING
- LARGE STRUCTURE MECHANICS
  - INSPECTION/TEST
  - PROCESS-WELDING, CUTTING, COATING, ETC.
- STRIPPING
- STORAGE AND RETRIEVAL
- FUELING/DEFUELING
- PLATING
- AIRCRAFT TOWING
- ELECTRONICS TESTING
- AIRCRAFT RIVETING/DERIVETING
- ORDNANCE DISPOSAL
- MOBILE SCAFFOLDING
- EXPLOSIVES MIXING
- CUTTING
- PATCHING AND REPAIR
- TOOL STORAGE/RETRIEVAL
- METAL SPRAYING/COATINGS

TRANSPORTABILITY AND MOBILITY

MANTECH NEEDS

- o PAINTING/STRIPPING
- o ELECTRONICS TESTING
- o RIVETING/DERIVETING
- o TANK CLEANING
- o LIGHTWEIGHT ROBOTIC STRUCTURES
- o MODULARITY/MAINTAINABILITY/SERVICEABILITY TECHNIQUES
- o STRUCTURAL LOADING INTERFACES

R&D ISSUES

- o MULTIFUNCTIONAL SYSTEMS
- o MULTI-MEDIA MOBILITY (TRACK, WHEEL, LEG, PROP, ETC.)
- o MULTI-APPENDAGE SYSTEMS (AND CONTROLS)
- o FUEL CELL/HIGH POWER DENSITY PACKAGES
- o POWER TRANSMISSION SYSTEMS
- o ON-BOARD NAVIGATION SYSTEMS
- o STABILITY AIDS/SYSTEMS
- o NUCLEAR HARDENING
- o ON-BOARD INTELLIGENCE
- o ENVIRONMENTAL ADAPTABILITY
- o FAIL-SOFT STRUCTURES
- o HIGH LOAD CAPACITIES (2 TONS)

THE DOD ROBOTICS APPLICATIONS WORKSHOP

October 4-7 1983

Sacramento, California

INTRODUCTION

The extraordinary pace of recent technology development and application in factory automation and robotics coupled with the pressing need to modernize and increase the productivity and performance of scarce resources in the organic industrial base of the Army, Navy, and Air Force led to the tri-service decision to conduct a DOD Depot Robotics Application Workshop Oct 4-7 1983, in Sacramento, California. This landmark event for the first time brought together - in a structured way-leading edge robotics practitioners possessing a proven track record of implementation successes in the private sector, and the Air Force, Army, and Navy depot personnel responsible for conception, planning, management, execution, and utilization of modernization and productivity enhancement projects.

The workshop represented a rare and never before achieved synergism of the entire in-house industrial base of the three services, focused on a single technology and its applications. The compelling scope, breadth, and depth of DOD organic industrial operations as revealed in the workshop presentations brought home to attendees a realization of the exceptional value and importance of this extraordinary industrial complex to the Department of Defense and the United States.

The workshop surfaced great interest and intent in Robotics and the instruments of automation because the current DOD depot, arsenal, shipyard, ordnance and supply, and aeronautical rework activity annual investment in direct touch labor is very large. The DOD Aeronautical Depots alone expended more than 82M direct manhours in FY 83 in in-house remanufacturing, maintenance, and repair of aeronautical weapon systems and associated products. Approximately one-half of this substantial investment was in the production of components, where direct touch labor is the dominant cost factor. Existing weapon systems acquisition plans and programs, if carried to reasonable percentage of execution, promise to further stress the current DOD work force and physical plant and its capacity to efficiently produce products in support of service operations. The application of labor-saving technology is thus seen as a mandatory adjunct to the continuing effort by service activities to improve performance and the utilization of limited plant, equipment, capital, and human resources.

Modernization of these precious and invaluable resources should hold an uncompromised priority in any balanced defense program. Too often, however, investments in the DOD in-house industrial complex are delayed or rejected in favor of investment in the weapons and products the DOD activities are chartered to support. The result is inevitably a continuing and burdensome growth in the life cycle cost of ownership of DOD assets, a corresponding decrease in the portion of the DOD dollar available for new weapon and military asset acquisition, and an ongoing deterioration in the overall vitality and efficiency of the service-organic industrial complex. Perhaps a Robotics and Automation pool of dedicated fiscal resources held, administered, and replenished at the DOD level and meritoriously competed on a project basis by the three services is what is required to insure that erosion of investment intent does not occur.

In any event, it is certain that aggressive and persistant long-term direction and action by the Congress and the Department of Defense are necessary to insure that the three services plan and vigorously implement a modernization program with short, mid, and long term components of capital-investment, technology transfer (mantech) and manufacturing research. The investment menu surfaced by the DOD Robotics

Applications Workshop represents an exceptional opportunity to appropriately dedicate fiscal resources to achieve specific, meaningful productivity and performance enhancement of the DOD in-house industrial base.

The workshop was structured as follows: (1) Private sector experts selected by The Robot Institute of America (RIA) conducted state-of-the-art Briefs on Robotics and Automation systems; (2) representatives of all the DOD industrial activities of the three services save one (Norfolk Naval Shipyard did not attend) presented briefs on their industrial processes and operations, process economics, current robotics projects, and plans for the future; and (3) brainstorming roundtables led by experts from private industry and staffed by DOD attendees took advantage of the enhancement and synergism effected by (1) and (2) to discuss and generate menus of needs and investment opportunities in current applications, technology transfer, and research for ten robotics-related technical areas. A multi-media evening program was included to facilitate total immersion in the technology of interest.

The benefits derived from the workshop were many. They included: (1) the opportunity for DOD industrial depot personnel to receive information on successful robotics techniques and applications now occurring in the private sector and at other DOD depots; (2) the opportunity for depot personnel to receive state-of-the-art briefs on current technology and a timetable on new developments in the robotics field; (3) the chance for participants to compare production problems, plans, and needs with other depot professionals in a structured exchange and problem solving environment; (4) a rare chance for attendees to influence the thrust and direction of a proposed manufacturing technology and applied research initiative - to be undertaken within the existing programmatic framework of the three services - whose purpose is to directly address both generic needs and specific application opportunities for robotics and allied automation technology in the service industrial depots; and (5) a unique chance for both depot and selected private sector invitees to be exposed to the process and application areas of our valuable in-house industrial complex, to the end of providing both the understanding of these capabilities and the stimulation to research, develop, and apply nuances of robotics and automation technology to industrial operations heretofore not considered for such an application. The workshop proved to be classically effective in terms of its direct and immediate benefit to participating DOD activities in their equipment, technology, and modernization planning and acquisition efforts. Further, it is believed that the participants' enhanced knowledge and understanding of a fountainhead automation technology will yield enduring long-term benefit to the production posture of the participating service organizations.

The workshop brought a mix of private sector principals from academia, the user community, original equipment manufacturers, turn-key systems houses, and consultant organizations to interact with DOD engineers and managers responsible for technical implementation and resource allocation decisions. The result was both a phenomenal growth in knowledge and understanding by all of both robotics technology and the activities of the DOD industrial base. From these interactions it became apparent to many attendees that many of the issues and developments of interest to the DOD industrial activities possess the potential for applicability in the marketplace. Thus, investments made in project opportunities surfaced by the workshop could ultimately provide significant leverage on the competitive posture of the U.S. robotics industry worldwide. The existence of this beneficial multiplier would seem to provide further impetus for prompt and sustained action by the DOD to pursue the investment menu in robotics research and technology developed by the workshop.

DOD ROBOTICS WORKSHOP CONCEPT

- Initiated by MTAG CAD/CAM and metals subcommittees
- All segments $10B/yr organic base
- Industrial process emphasis
- Service-private sector information exchange
- RIA-managed industry participation
- Goal: Investment opportunity identification
  - Current applications
  - MANTECH
  - R&D
- Goal: Enhanced tri-service industrial base technology emphasis
- Goal: DOD sponsored tri-service depot focused technology investment program

WORKSHOP STRUCTURE

- Robotics briefs (RIA)
  - State of the art
  - Current installations/experience
  - The future: projections
- The DOD organic industrial base
  - Basic processes/technologies
  - Process economics
  - Current robotics/automation installations
  - Planned/future applications
- Roundtables
  - Ten related topics
  - Eight roundtables
  - Three sessions/topics
  - Led by private sector
  - Roundtable products
    - Process-technology matches (current)
    - MANTECH depot robotics needs
    - Depot robotics research needs

DOD ROBOTICS WORKSHOP

Multi-media
Evening Program

Speaker	Affiliation	Topic	Date
Victor Scheinman	Automatix, Inc.	"A CAM Update"	4 Oct
R. Hahn	Cincinnati MILACRON	"Applied Robotics"	4 Oct
J. Atkinson	Cincinnati MILACRON	"Applied Robotics"	4 Oct
B. Whetsel	Cincinnati MILACRON	"Applied Robotics"	4 Oct
Vern Estes	General Electric	"Robot Applications"	4 Oct
Tom Hilditch	Dept of Energy	"Robot Applications"	4 Oct
Roger Nagel	Lehigh University	"New Manufacturing Systems"	5 Oct
Ken Lenzillo	Portsmouth Navy Yard	"Production Line Concept for Overhauling Submarines"	5 Oct
John Evans	NOVA Robotics	"Robotics"	5 Oct
Dave Anderson	Ford Motor Company	"Robotics Applications"	5 Oct

ROBOTICS APPLICATION WORKSHOP STAFF

SERVICE CHAIRS;	
ARMY:	ROBERT HELLEM, IBEA,DRXIB-MM
AIRFORCE:	LAZLO HARY, HQ AFLC/MAXT
NAVY:	FORREST GALE, DSMC (HQ NAVMAT)
DOD ROBOTICS APPLICATION WORKSHOP CHAIRMAN:	WILLIAM WALDEN, SM-ALC/MAW
PRESIDENT OF SOLE:	SUE O'NEIL, SM-ALC/MMI
FINANCE MONITOR OF SOLE:	MARILYN MILLER, SM-ALC/MMK
FINANCE MONITOR OF MA:	PAT DWYER, SM-ALC/MAW
ACCOMMODATIONS PLANNER:	KAREN HARPER, SM-ALC/MAW
AUDIO-VISUAL AND PUBLICATIONS:	GEORGE ANDERSON, SM-ALC/MAA MIKE CHANDLER, SM-ALC/MAA BETTY HOYT, SM-ALC/MAA DON HAMMERSTEN, SM-ALC/MAA KEITH DANKERTSEN, SM-ALC/MAW
PROTOCOL:	SHEILA MCFALL, SM-ALC/MAA MARSHA WALLACE, SM-ALC/MAA
ADMINISTRATIVE ASSISTANT:	EDNITA R. OVERSTREET, SM-ALC/MAW

Presentation Subject Overview

The objective in a data matrix prepared for presentation at the DoD Depot Robotics Workshop is to provide the maximum amount of procedural, economic, and technical information possible in as compressed and summary a format as possible. The basic subjects to be presented by the DoD activities are:

1. Industrial Processes/Sequences
2. White Collar (staff) Processes
3. Current Robotics Projects
4. Planned Robotics Projects
5. Potential Robotics Projects

The basic subjects to be presented by the private sector invitees are:

A. Robotics Overview
   1. What are robot systems, parameters, specifications, etc.
   2. Current applications
   3. What robots can do
   4. Limitations/caveats and "experiences."
   5. State-of-the-art: What is new and what is coming soon.
   6. Current research and development efforts
   7. A view of the future: Total systems integration.

B. Robotics Project Mini-Tutorial
   1. Robotics application assessment
   2. Robot cost/pay back analysis
   3. Robot investment decision analysis
   4. Robot implementation
      a. System installation/checkout
      b. System integration
      c. etc.
   5. Robot life cycle support
      a. Maintenance (Hardware)
      b. Training/work force program
      c. Software support/maintenance
      d. Technical data
      e. etc.

DOD ROBOTICS APPLICATION WORKSHOP

Presentors and Participant Guide

Presentors:

1. All private sector presentations will be free of marketing or sales effort; the goal is maximum transfer of technical information to participants.

2. All presentations are to be developed utilizing either vu-graphs or 35/42mm slides.

3. Hard copies of all presentation material must be provided to the workshop coordinator prior to September 1 so it can be used in assembling a workshop handbook.

4. All presentations are to be as detailed as possible in the time allotted. Depot presentations on process detail should include: (a) process name; (b) a chart of a typical process sequence; (c) touch labor operations should be noted for emphasis; and (d) the economic significance of the process should be noted (i.e., number of units, labor hours per current unit of output, most costly operations in the sequence, hazardous or unpleasant environmental conditions, etc.).

5. Summary and matrix charts are to be used whenever possible to compress information.

Participants:

1. You must prepare for this workshop. If you are from a depot, you must be prepared to discuss the following: (a) the principal industrial processes at your activity; (b) the basic process sequences; (c) the economic significance (ranking) of same; (d) the business volume for each process now and as projected for the mid-term (3 years) horizon; (e) the extent of touch labor in the current process; (f) modernization plans (if any) for your activity, and their potential effect on the principal industrial process sequences at your activity; (g) current and planned robotics projects at your activity, including both technical and administrative project detail; and (h) the projected future process and technology needs of your depot, based on the best available workload projections.

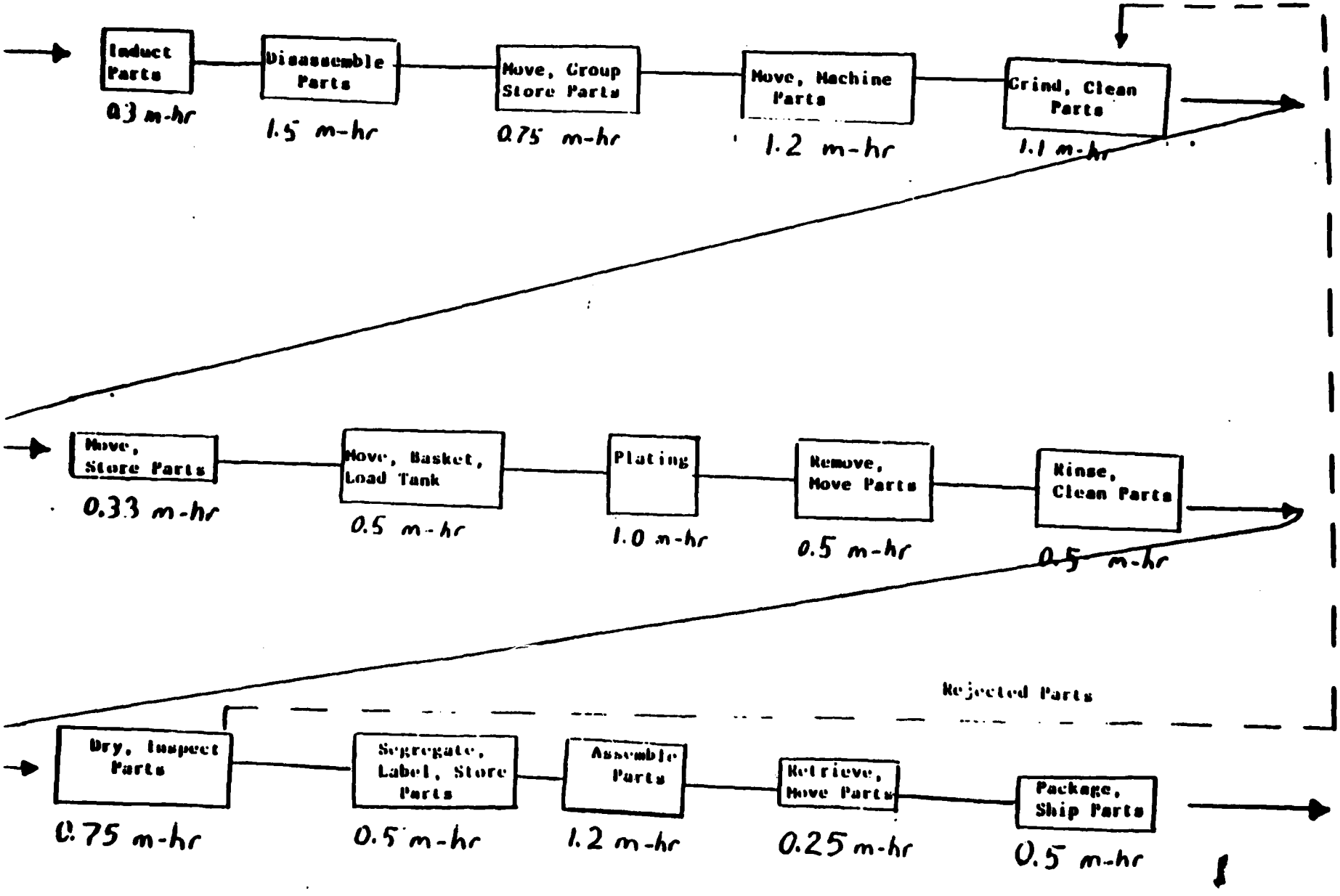
SAMPLE PROCESS INFORMATION MATRIX FORMAT

Process	Touch Labor Hrs/yr (k)	Total Cost yr ($)	Hazardous/ Unpleasant work env.	Labor Skill Required	Job Training	Key OPN's Common to other Processes
Welding	50	1,500	yes	high	2 yr appr.	yes
Metal Cutting/ Forming	42	1,260	yes	Mod-high	4 yr appr.	yes
Electrical Test	190	5,700	no	high	4 yr appr.	yes
Disassembly	960	28,800	no	low	1 yr trng.	yes
Assembly	1,020	30,600	no	high	4 yr appr.	yes
Material Handling	955	28,650	no	low	3-6 month OJT	yes
Material vement/ ting	292	8,760	no	low	3 month OJT	yes
Packaging/ Pres	112	3,360	no	mod	1 yr trng. and OJT	yes
Material Storage/ Retrieval	60	1,800	no	low	6 month trng. and OJT	no
Parts Cleaning	27	810	yes	low	3 month OJT	no
Deburring & Finishing	17	510	yes	mod	2-4 yr appr.	no
Plating	14	420	yes	high	4 yr appr. & OJT	no
Heat Treating	11.5	345	yes	mod-high	4 yr appr. & OJT	no
AAAABXY	ZZZZZ	NNNN	yes	high	4 yr appr.	yes
Totals						

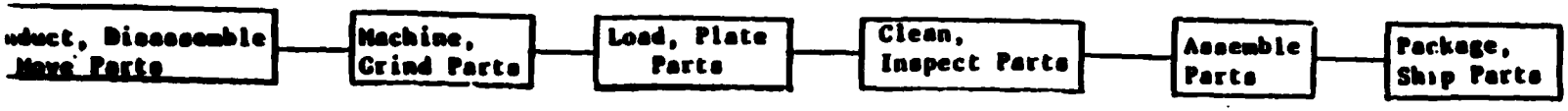
Other columnar data titles of interest might include the following: "Boring/ titive", "Precision Required", "Product Design Complexity", Product Fragility", terial Cost", "Scrap Rate", "Part Size", "Part Weight", "Support Equipment Maint. Cost", "Skilled Labor Availability", "Unit Product Volume/yr", "Process Environment", etc.

SAMPLE DETAILED PROCESS ANALYSIS

Process: Plating



SAMPLE SUMMARY ANALYSIS OF PREVIOUS SEQUENCE



2.55 m-hrs | 2.63 m-hrs | 2.00 m-hrs | 1.75 m-hrs | 1.2 m-hrs | 0.75 m-hrs

TAILED PROCESS SEQUENCE:

tal man-hours: 10.88/load
tal labor hours/yr.: 14,000
tal labor cost/yr.: $420,000
tal parts loads /yr: 1,287
erage loads /day: 4.9
st/load (@$30/m-hr): $326.40
rts /load: 100
jection rate: 10%
g. Labor cost/part: $3.60

- Disassembly, handling: 80¢
- Machining, grinding, handling: 80¢
- Plating, handling: 70¢
- Cleaning, inspecting, handling: 60¢
- Assembly: 40¢
- Packaging and shipping: 30¢

SAMPLE ROBOTICS PROJECT SUMMARY INFORMATION MATRIX

Activity: Aircraft Depot XYZ

Project	Date	Project Mgr.	Cost	Process Automated	ECD	Misc.
Automated Tail Bender	FY 82	Jay Endeffector	240	Straighten F&U Tails	6/84	Utilizes Laser Holograph Vision System
Robotic Tire Tester	FY 83	Lionel Gripper	330	Auto Test and handle Guy Rubber Tires	9/85	Multi-arm Robot Bounce-Tests Tires
Small Parts Fetch	FY 84	Fred Tactile	150	Walking Robot Inter-Facing with Small Parts Bin-dump	1/85	Aircraft Small Parts on Prod. Floor. Voice Programmable
Apprentice Chute Trainer	FY 81	Geronimo R2D2	230	Robot Packs and Tests Parachutes	Comp.	Chute Redesign to accommodate robot robot pack

The object here is to provide a quick compressed summary of robotics projects in execution, completed, and planned. This is only a sample summary. Other columnar headings which might be relevant include: "Unique Features", "Special Problems", "Payback Period", "Type of Installation" (i.e. stand alone, system integration, etc), "Software Language", etc., etc.

AGENDA

DOD ROBOTICS APPLICATION WORKSHOP

Sierra Inn, Sacramento, CA

Redwood Ballroom

MONDAY, 3 Oct 83

1600 - 2000	Registration	Sierra Inn Pecan Room

TUESDAY, 4 Oct 83

0700 - 0900	Registration	Sierra Inn, Room 151
0800 - 0810	Welcome	Brig Gen T.A. Hammond Vice Commander, Sacramento Air Logistics Center
0810 - 0815	Workshop Administrative Details	W. Walden, SM-ALC
0815 - 0825	Introduction	J. Sullivan, IBEA
	OVERVIEW OF THE STATE-OF-THE-ART IN ROBOTICS AND APPLICATION ASSESSMENT SESSION Moderator: Dr K. McKee, Manufacturing Productivity Center	
0830 - 0850	Robot implementations and associated benefits	V. Estes, General Electric Co.
0850 - 0910	Current robot applications and direction of research	D. Anderson, Ford Motor Co.
0910 - 0930	Robot system experiences, successes and failures	R.M. Hills, General Dynamics Corp.
0930 - 0950	Robot systems performance and capabilities	R. Hinson, Robot Systems Inc.
0950 - 1010	Overall analysis of current robot systems	R. Hohn, Cincinnati Milacron
1010 - 1025	Break	
1025 - 1045	State-of-the-art in applied research and its direction	Dr R. Nagel, Lehigh University

1045 - 1105	Robot technology and human factors	J.E. Taylor, HumRRO
1105 - 1125	General issues for manufacturing policy - balance for R&D	Dr D. Tesar, University of Florida
1125 - 1145	Current successful robot applications	G. VanderBrug, Automatix Inc.
1145 - 1205	Robot welding systems	J. Fouse, Vought Corp.
1205 - 1225	The future - What does the next decade hold?	M. Knasel, Science Applications Inc.
1225 - 1345	Lunch	
	DEPOT PROCESS REVIEW SESSION	
	Moderator: F. Gale, Defense Systems Management College	
1345 - 1400	Air Force Aircraft Repair	G. Langenbeck, SM-ALC/MAB
1400 - 1415	Air Force Engine Repair	M. LeBlanc, OC-ALC/MAE
1415 - 1430	Air Force Electronics Repair	W. Ramsey, WR-ALC/MAI
1430 - 1445	Air Force Landing Gear Repair	Lt Col Hruskocy OO-ALC/MAN
1445 - 1455	Navy Depot processes	NARF Alameda
1455 - 1505	Navy Depot processes	NARF Cherry Point
1505 - 1515	Navy Depot processes	NARF Jacksonville
1515 - 1525	Navy Depot processes	NARF Norfolk
1525 - 1535	Navy Depot processes	NARF North Island
1535 - 1545	Navy Depot processes	NARF Pensacola
1545 - 1600	Break	
1600 - 1700	Navy Shipyard processes	NSY Charleston
	Navy Shipyard processes	NSY Long Beach
	Navy Shipyard processes	NSY Mare Island
	Navy Shipyard processes	NSY Norfolk
	Navy Shipyard processes	NSY Pearl Harbor
	Navy Shipyard processes	NSY Philadelphia
	Navy Shipyard processes	NSY Portsmouth
	Navy Shipyard processes	NSY Puget Sound

1700 - 1720	Question/Answer and Discussion	
1720	Adjourn	
1720 - 1735	Roundtable Leaders Meeting	Location to be announced.
1830 - 2030	No Host Social Hour	Redwood A Room
2030 - 2200	Evening program, to be announced.	Pecan and Sequoia Rooms

WEDNESDAY, 5 Oct 83

DEPOT PROCESS REVIEW SESSION - CONTINUED

Moderator: J. Sullivan, IBEA

0800 - 0820	Exploration & analysis of process sequences	J. Nitterhouse, Letterkenny Army Depot
0820 - 0830	Current operation and economics of welding, plating, painting and van assembly	E. Helalian, Sacramento Army Depot
0830 - 0845	Combat vehicle track and suspension overhaul and conversion operations	W. Oosterveen, Red River Army Depot
0845 - 0900	Overhaul of communications - electronic shelters	F. Estock, Tobyhanna Army Depot
0900 - 0915	Use of robotics in material handling of hazardous materials	F. Eldriege, Tooele Army Depot
0915 - 1000	Navy Weapon Stations Ordnance Depots " " " " " " "	NWS Charleston NWS Concord NWSC Crane NWS Earle NOS Indian Head NUWES Keyport NOS Louisville NWS Seal Beach NWS Yorktown
1000 - 1015	Break	

CURRENT DEPOT ROBOTICS PROJECTS SESSION

Moderator: L. Hary, AFLC/MAXT

1015 - 1025	Air Force, Blade Repair	M. LeBlanc, OC-ALC/MAE

1025 - 1035	Air Force, Plasma Spray at SA-ALC	S. Lee, AFWAL/MLTM
1035 - 1045	Air Force, Honeycomb Shaping at SM-ALC	G. Betz, Robotic Vision
1045 - 1055	Air Force, Robotic Painting	Col R. Grabler, OO-ALC/MAW
1055 - 1120	Navy Robotics projects	NARFS
1120 - 1130	Navy Robotics projects	YARDS
1130 - 1135	Navy Robotics projects	NWS/NOS
1135 - 1145	Neo-robotic application development	J. Nitterhouse, Letterkenny Army Depot
1145 - 1155	Feasibility and economic considerations of robotic applications at welding shop	E. Helalian, Sacramento Army Depot
1155 - 1205	Robotic applications to combat vehicle track and suspension overhaul and conversion operations	W. Oosterveen, Red River Army Depot
1205 - 1215	Application of robotics to shelter refinishing	S. O'Malley, Tobyhanna Army Depot
1215 - 1325	Lunch	
	POTENTIAL DEPOT APPLICATIONS AND PLANS FOR THE FUTURE	
	Moderator: J. Sullivan, IBEA	
1335 - 1345	DLA Depot Automation	Col T. Kirkham, Defense Logistics Agency
1345 - 1355	Laser Paint Removal	T. Mallets, AFLC/MAXT
1355 - 1405	Air Force Materials Laboratory Plans/Projects	S. Lee, AFWAL/MLTM
1405 - 1415	AIM Industry/Depot Survey	F. Brooks, AFSC/PMI
1415 - 1425	OO-ALC plans	Col R. Grabler, OO-ALC/MAW
1425 - 1435	SA-ALC plans	Lt Col J. Ferry, SA-ALC/MAW

1435 - 1445	Robotics in NDI, SM-ALC	D. Froom, SM-ALC/MAN
1445 - 1500	Navy plans	NARFS
1500 - 1515	Navy plans	Shipyards
1515 - 1530	Break	
1530 - 1545	Navy plans	NWS/NOS
1545 - 1600	Navy plans	NCS San Diego/ NAVSUPHQ PWC/NAVFACHQ
1600 - 1610	Robotic systems for camouflage painting, welding, laser engraving and the integration of state-of-the-art end effectors to planned systems.	J. Nitterhouse, Letterkenny Army Depot
1610 - 1625	Engineering and economic considerations of potential robotic applications	E. Helalian, Sacramento Army Depot
1625 - 1635	Robotic camouflage painting of the M113 vehicle family	W. Oosterveen, Red River Army Depot
1635 - 1700	Field applications for robotic material handling systems	C. Shoemaker, Human Engineering Laboratory, and F. Eldriege, Tooele Army Depot
1700 - 1730	Questions & Answers	
1730	Adjourn	
2030 - 2200	Evening program, to be announced.	Pecan and Sequoia Rooms

THURDAY, 6 Oct 83

ROUNDTABLE SESSIONS

Locations to be posted.

Moderator: F. Gale,
Defense Systems Management
College

0800 - 0910	Simultaneous Roundtables - Session 1 (see attachment for topics and leaders)	Government & Industry
0910 - 1020	Simultaneous Roundtables - Session 2 (see attachment for topics and leaders)	Government & Industry
1020 - 1035	Break	
1035 - 1145	Simultaneous Roundtables - Session 3 (see attachment for topics and leaders)	Government & Industry
1145 - 1305	Lunch	
1305 - 1515	Roundtable Summary Presentations (10 each, 13 min presentations)	Chairpersons
1515 - 1530	Break	
1530 - 1700	Open Discussion & Wrap-up Summary	J. Sullivan, IBEA
1700	Adjourn	

FRIDAY, 7 Oct 83

0830 - 1130	Tour of SM-ALC Production Operations (Optional)	
or		
0800 - 1600	Robotic Conference at California State University, (Optional -- See Flyer: "Towards Intelligent Robots.")	

NOTE: Registration/reception desk will be open on Monday, 3 October from 1600 - 2000 in Pecan Room, Sierra Inn. The desk will be open in Room 151 from 0700 - 0900 on Tuesday, 4 October to accommodate late arrivals.

DOD ROBOTICS APPLICATION WORKSHOP

ROUNDTABLE SESSIONS

Moderator: **F. Gale,**
Defense Systems Management College

	Roundtable Topics	Leaders
1.	Potential Applications	V.E. Estes, General Electric Co. D. Anderson (co-leader), Ford Motor Co.
2.	Robot Installation/Design Concepts	R. Hinson, Robot Systems Inc.
3.	Robot Safety/Security	R. Hohn, Cincinnati Milacron
4.	Robot Language Concepts/Development	Dr R. Nagel, Lehigh University
5.	Robot Mechanical Systems/Precision Operations	Dr D. Tesar, University of Florida
6.	Robot Vision	G. Betz, Robotic Vision Systems Inc.
7.	Robot Control and Integrated Systems	J. Evans, Nova Robotics Inc.
8.	Robot Hands and End Effectors	R. Hills, General Dynamics Corp.
9.	Topic to be Announced	G. VanderBrug, Automatix Inc.
10.	Robot Transportability/Mobility	M. Knasel, Science Applications Inc.

DOD ROBOTICS APPLICATIONS WORKSHOP ATTENDEES

Kay Abel
Directorate of Distribution/DSMD
McClellan AFB, CA 95652

Donald R. Allen
HQ AFLC/DS (LOGMARS)
Wright-Patterson AFB, OH 45433

Harlow R. Austin
Directorate of Maintenance/MAIESB
Warner-Robins AFB, GA 31098

Larry N. Belcher
Naval Ordnance Station/M. D. S. 2
Louisville, KY 40214

Billie R. Beller
Directorate of Maintenance/MAIEG
McClellan AFB, CA 95652

James D. Bentley
HQ AFLC/DSSP
Wright-Patterson AFB, OH 45433

John A. Bogen
Naval Undersea Warfare Engr Station
Keyport, WA 98345

Frederick Brooks
AFSC/PMI
Wright-Patterson AFB, OH 45433

Robert W. Brown
Directorate of Distribution/DSME
Warner-Robins AFB, GA 31098

Jim W. Burch
OC-ALC
Tinker AFB, OK 73145

John Burt
Directorate of Maintenance/MAIP
McClellan AFB, CA 95652

Sherman Chan
AFALD
Wright-Patterson AFB, OH 45433

Patrick J. Coghlan
Sacramento Army Depot/SDSSA-RPM-1
Sacramento, CA 95813

William R. Cokeley
Naval Air Rework Facility VAX
Jacksonville, FL 32212

Ronald Colby
Directorate Distribution
Hill AFB
Ogden, UT 84406

Mary Jean Cook
Naval Materiel Command/MAT-01M12
RM 924CP5
Washington, DC 20360

V. L. Cooper
Code 900
Naval Air Rework Facility, North Island
San Diego, CA 92135

Harris Cooper
Naval Air Rework Facility Code 960
Norfolk, VA 23511

Kay D. Davis
Directorate Plans and Programs/XRXA
Kelly AFB, TX 78241

Robert Didocha
Georgia Institute of Technology
EES/TAL
Atlantic, MA 30332

Christopher Dunlap
Naval Air Rework Facility Pensacola
Pensacola, FL 32508

Harry Ehlers
Directorate of Distribution
Kelly AFB, TX 78241

Fred Eldredge
Directorate for Ammunition Equipment
Tooele Army Depot, UT 84074

A. Elshinnawy
Naval Air Engr Center Code 92A3
Lakehurst, NJ 08733

Dr. Robert W. Elwood
Naval Supply Systems Command/Sup-033B HQ
Washington, DC 20376

Edwin L. Emerson
US Army Matl & Mech Research Center
Watertown, MA 02172

William Emmons
Directorate of Maintenance/MAQC
McClellan AFB, CA 95652

Dean Eppley
Directorate of Distribution/DSME
McClellan AFB, CA 95652

Vern Estes
General Electric Company
Bldg 10A - Rm 109A
1 River Road
Schenectady, NY 12345

Frank Estock
DESCOM
Tobyhanna Army Depot, PA 18466

John M. Evans
NOVA Robotics
265 Prestige Park Road
East Hartford, CT 06108

Charles E. Feenstra
HQ AFLC/MAXF
Wright-Patterson AFB, OH 45433

LtCol J. D. Ferry
Directorate of Maintenance/MAWP
Kelly AFB, TX 78241

Forrest Gale
Director, Laboratory Department
Room 120, Building 209
Defense Systems Management College
Fort Belvoir, VA 22060

Joe Gallegos
Directorate of Maintenance/MATEE
Kelly AFB, TX 78241

Heinz Gilles
Mainz Army Depot SDSMZ-MIP-PGO
Germany, NY 09185

Richard Ginnett
SM-ALC
McClellan AFB, CA 95652

Donna L. Glick
HQ AFLC/DSXE
Wright-Patterson AFB, OH 45433

Fred K. Gordon, Jr.
Directorate of Maintenance/MAWF
Warner-Robins AFB, GA 31098

COL Ronald V. Grabler
Directorate of Maintenance/MAW
Hill AFB, UT 84406

Robert O. Guyman
Naval Weapon Station
Concord, CA 95420

Brian T. Hagerty
Naval Weapons Station
Yorktown, VA 23185

Maj Ronald H. Hardy
AFSC/AFWAL/MLSS
Wright-Patterson AFB, OH 45433

Lester Hartzel
Long Beach Naval Shipyard
Long Beach, CA 90822

Laszlo Hary
HQ AFLC/MAXT
Wright-Patterson AFB 45433

Lawrence J. Head
HQ AFLC/MAXF
Wright-Patterson AFB, OH 45433

David O. Heape
Naval Weapons Station
Yorktown, VA 23185

Ed Helalian
Sacramento Army Depot
Sacramento, CA 95825

Robert S. Hellem
US Army Ind Base Engr Act DRXIB-MM
Rock Island, IL 61299

F. Henson
MARE Is. Naval Shipyard
Code 380.35
Building 866, Stop T47
Vallejo, CA 94592

Thomas E. Hildick, Jr.
Department of Energy
Pinellas Plant-GE, FL 33565

Ronald M. Hills
General Dynamics
P.O. Box 748
MZ6443
Fort Worth, TX 76101

Sharon Hogge
NSWC/White Oak
Silver Spring, MD 20907

Henry E. Hogue
Defense Industrial Plant Equipment Center
Memphis, TN 38114

LtCol Thomas C. Hruskocy
Directorate of Maintenance/MAN
Hill AFB, UT 84406

Clyde E. Hudson
Naval Undersea Warfare Engr Station
Keyport, WA 98345

Elwin Jang
Directorate of Maintenance/MANEF
McClellan AFB, CA 95652

Henry A. Johnson
AFWAL/MLT
Wright-Patterson AFB, OH 45433

Jean-Paul Kabbara
Directorate of Maintenance/MACE
McClellan AFB, CA 95652

Mike Khosrovi
Directorate of Maintenance/MAW
McClellan AFB, CA 95652

Mike King
US Army Tank Automotive Command
Warren, MI 48090

Colonel Thomas L. Kirkham
Defense Logistics Agency
Cameron Station
Alexandria, VA 22314

Phillip Klutts
Directorate of Maintenance/MATEE
Tinker AFB, OK 73145

William Koop
Naval Weapons Station/I. E. Div
Seal Beach, CA 90740

Jack N. Kotyk
Directorate of Maintenance/MACE
McClellan AFB, CA 95652

Kenneth F. Lanzillo
Portsmouth Naval Shipyard
Portsmouth, NH 03801

John M. Ledden
HQ AFLC/MAX
Wright-Patterson AFB, OH 45433

Sylvester O. Lee
AFWAL/MLTM
Wright-Patterson AFB, OH 45433

Herbert L. Leonard
HQ AFLC
Wright-Patterson AFB, OH 45433

Joseph Lester
Nav Aviation Log Cntr Code 332G
Patuxent River, MD 20670

Kenneth Lillie
AFSC/AFWAL - Materials Lab
Wright-Patterson AFB, OH 45433

Maurice LeBlanc
OC-ALC
Tinker AFB, OK 73145

Thomas J. Mallets
HQ AFLC
Wright-Patterson AFB, OH 45433

Robert T. Mason
Office of the Secretary of Defense
OASD(MRA & L) LMM/MD
The Pentagon
Washington, DC 20301

William Maxwell
Naval Air Rework Facility Code 640
Norfolk, VA 23511

RADM D. P. McGuillivary
(DLA-Z) Cameron Station
Alexandria, VA 22314

Tom Meany
536 Broadhollow Road
Melville, NY 11747

Gary J. Meier
NAVFACENGCOM HQ
200 Stovall Street
Alexandria, VA 22332

Alfred Messersmith
Long Beach Naval Shipyard
Long Beach, CA 90822

CAPT P. A. Monroe
Code 00
Naval Air Rework Facility, North Island
San Diego, CA 92135

Ronald L. Morton
Directorate Plans and Programs/XRS
Warner-Robins AFB, GA 31098

Roger N. Nagel
Lehigh University
Packard Lab #19
Bethelehem, PA 18015

Anhvu Nguyen
Directorate of Maintenance/MABER
McClellan AFB, CA 95652

C. W. Nugent
Code 385.2 Charleston Naval Shipyard
Charleston, SC 29408

J. P. O'Brien
Naval Air Rework Facility (Code 642)
MCAS Cherry Point, NC 28533

Steven O'Malley
DESCOM
Tobyhanna Army Depot, PA 18466

Ronald L. Orr
Directorate of Maintenance/MAN
McClellan, CA 95652

Robert J. Palk
Code 600
Naval Air Rework Facility, North Island
San Diego, CA 92135

COL Elbert C. Parker
ADS/AEM(RA)
Wright-Patterson AFB, OH 45433

John D. Pine
HQ AFLC/MAXT
Wright-Patterson AFB, OH 45433

Rod A. Pratt
Naval Ordnance Station
Indian Head, MD 20640

Dennis N. Prichard
Directorate of Maintenance/MAWFP
Warner-Robins AFB, GA 31098

William C. Ramsey, Jr.
Directorate of Maintenance/MAIES
Warner-Robins AFB, GA 31098

Matthew Reilly
Lehigh University
Director of Research Prog Development
Bethlehem, PA 18015

Joseph W. Renteria
Mainz Army Depot SDSMZ-FMD
Germany, NY 09185

COL Bill Rimes
Bldg T-113/DGSC
Richmond, VA 23297

Gordon Robbins
DMM/MMMMT
McClellan AFB, CA 95652

Elwin A. Rozybkie
Directorate of Distribution
Kelly AFB, TX 78237

Michael W. Rush
AGMC/MAWF
Newark, OH 43055

John S. Sarosky
Puget Sound Navy Shipyard Code 385.12
Bremerton, WA 92314

Victor Scheinman
VP Automatrix Inc.
30 Roan Place
Woodside, CA 94062

Nick Schrier
Directorate of Distribution/DSME
McClellan AFB, CA 95652

L. A. Senhen
Naval Supply Center
San Diego, CA 92132

Thomas J. Shea
DARCOMPSCC/SDSTO-TP-P
Tobyhanna, PA 18466

Dean Shimek
Nav Wpn Sta/Pomona Annex
Seal Beach, CA 90740

Bob Shrum
Directorate of Maintenance/MAWFP
Kelly AFB, TX 78241

Louis H. Smith
Long Beach Naval Shipyard
Long Beach, CA 90822

Edward Smith
Naval Air Logistics Center Code 332
Patuxent River, MD 20670

Lawrence M. Smith
SA-ALC/MMEA
Kelly AFB, TX 78241

Howard Stearn
536 Broadhollow Road
Melville, NY 11747

Charles Stechman
Directorate of Distribution/DSME
McClellan AFB, CA 95652

Richard E. Stephens
OO-ALC
Hill AFB, UT 84406

Paul Storey
SM-ALC/MME1E
McClellan AFB, CA 95652

James H. Sullivan
US Army Ind Base Engr Act DRXIB-MT
Rock Island, IL 61299

Jim Snyder
Directorate of Maintenance/MABER
McClellan AFB, CA 95652

Alvin K. Takemoto
US Army Mgt Engr Trng Actv/DRXOM-SE
Rock Island, IL 61299

Carl L. Tarpley
Charleston Naval Shipyard-D
Charleston, SC 29408

John E. Taylor
Human Resources Research Organization
Alexandria, VA 22314

Gerald Tietje
Code 610, Building #2
Naval Air Rework Facility, North Island
San Diego, CA 92135

Thomas V. Tolson
Naval Air Rework Facility (Code 016)
MCAS Cherry Point, NC 28533

Michael A. Travisano
Earle Naval Weapons Station
Colts Neck, NJ 07722

John Trick, Jr.
Naval Ordnance Station Code 511
Indian Head, MD 20640

Paul Ventura
Aerojet Bldg. 2004 Dept 7500
Sacramento, CA 95825

Kenneth Vincent
AFALD/RAX
Wright-Patterson AFB, OH 45433

Wesley Ward
Naval Air Rework Facility
Jacksonville, FL 32212

COL Donald Wells
Directorate of Maintenance/MAW
Kelly AFB, TX 78241

Morris J. Wexler
Directorate Plans and Programs/XRS
Kelly AFB, TX 78241

Tommy C. White
Directorate of Maintenance/MABEP
Tinker AFB, OK 73145

Ronald W. Wimmer
Naval Aviation Logistics Center
Patuxent River, MD 20670

Richard Wolff
Naval Air Rework Facility
Jacksonville, FL 32212

Joel Yuen
Pearl Harbor Shipyard Box 400
Pearl Harbor, HI 96860

David Anderson
Applications Consulting Center
Ford Motor Company
15100 Mercantile Drive
Dearborn, MI 48120

Gerald Betz
536 Broadhollow Road
Melville, NY 11747

William E. Brand
704 Cheryl Ann
Wentzville, MO 63385

Richard Carr
No address given

James Cherry
No address given

Kresten Cook
No address given

Louis DeRosa
122 S. Lipincott Avenue
Maple Shade, NJ 08052

Robert Estacio
No address given

LtCmdr Robert Everett
NAVSEASYSCOM HQ, SEA 90M
Washington, DC 20361

Winslow Foster
No address given

Jack A. Fouse
5305 Mona Lane
Dallas, TX 75236

Garry L. Fuller
301 Village Lane
Wake Village, TX 75501

Stephen J. Guilfoos
4713 Polen Drive
Kettering, OH 45440

Fred C. Henson
P.O. Box 4285
Vallejo, CA 94590

Richard E. Hohn
215 S. West Street
Lebanon, OH 45036

Mary Imhof
No address given

Jerry Jackson
No address given

Richard J. Jeffrey
8229 Post Road
Fair Oaks, CA 95628

John Johnson
2216 Sussex Drive
Bloomington, IN 47401

Ray S. Jones, Jr.
3153 Babashaw Ct.
Fairfax, VA 22031

Steve Kalabakes
32 Brindle Drive #3
Fayetteville, PA 17222

M. Knasel
SAI Inc.
1710 Goodridge Drive
McLean, VA 22102

CAPT Robert Kogler
NAVAIRSYSCOM HQ, Code 514
Room 1012 JP-2
Washington, DC 20361

Dave Lawson
No address given

Lee Mangrum
14038 Bluefin Drive
Woodbridge, VA 22193

Orlando Miguel
29 Ryon Court
Waldorf, MD 20601

Ms. Raye J. Montague
902 Linwood Street
W. Hyattsville, MD 20782

Manuel Morante
No address given

Robert Morris
No address given

Jean Morrison
No address given

Keith E. McKee
ITT Research Institute
10 W. 35th Street
Chicago, IL 60616

John O'Hagan
2 Foxwood Lane
Medford, NJ 08055

Walt Oosterveen
1018 Champion
Texarkana, TX 75501

Henry F. Peesel
9827 Laurel Street
Fairfax, VA 22032

Major Peter T. Pesenti
8634 Woodview Drive
Springfield, VA 22153

Leo Plonsky
208 N. Deerwood Drive
Westchester, PA 19380

Richard L. Riney
1209 Edgar Avenue
Chambersburg, PA 17201

Alton A. Samsel
87 Pulliana Street
Pleasanton, TX 78064

Barry Savnik
No address given

Daniel M. Sheets
4840 Springfield Street
Dayton, OH 45431

Calvin Smith
5313 Caldeonia Road
Richmond, VA 23225

Robert W. Taylor
78 Brisbane Drive
Charleston, SC 29407

Delbert Tesar
300 MEB
University of Florida
Gainesville, FL 32611

Robert Trouteaud
9685 North Pond Circle
Roswell, GA 30076

Roy Wells, Jr.
4802 Dauron Street
Laurel, MD 20707

Jere D. Whirley
402 Grouse Road
Summerville, SC 29483

Mahlon S. Wilson
18-8860 Pacific Avenue, NW
Silverdale, WA 98383

Tristan Zaia
2812 38th Street, NW
Washington, DC 20007

William Walden
JM-ALC/MAWFP
McClellan AFB, CA 95652